Error estimation in an optimal interpolation scheme for high spatial and temporal resolution SST analyses

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Motivation

• Heat and moisture exchange between ocean surface and atmosphere plays integral role in short-term, regional NWP

•Current SST products lack both spatial and temporal resolution to accurately capture small-scale features that affect heat and moisture flux

• NASA satellite used to produce high spatial and temporal resolution SST analysis using an OI technique

Background

• NASA SPoRT has developed compositing techniques for producing four-times daily, 1 km SST products

•Techniques include only temporal weighting, leading to pixel-to-pixel variations in composites, often appearing as unrealistic or false gradients

•Data assimilation is promising technique because of ability to spatially spread information

Methods

• OI technique with Gaussian covariance function implemented for simplicity (Cummings, 2006)

$$Cov = (1 + s_h)e^{-s_h}$$

$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{P}_b\mathbf{H}^T(\mathbf{H}\mathbf{P}_b\mathbf{H}^T + \mathbf{R})^{-1}\{\mathbf{y}_o - \mathbf{H}(\mathbf{x}_b)\}$$

• s_h is distance between points, normalized by correlation length scale, $\mathbf{x}_a$ is the analysis field, $\mathbf{P}_b$ is the background error covariance, $\mathbf{R}$ is the observation error, $\mathbf{y}_o - \mathbf{H}(\mathbf{x}_b)$ is the observation increment, and $\mathbf{H}$ is an operator to transform model space to observation space

•MODIS and AMSR-E data used as observations

•Objective is to create a spatially consistent, 1 km regional SST map for the August 2008-September 2008 period over tropical Atlantic

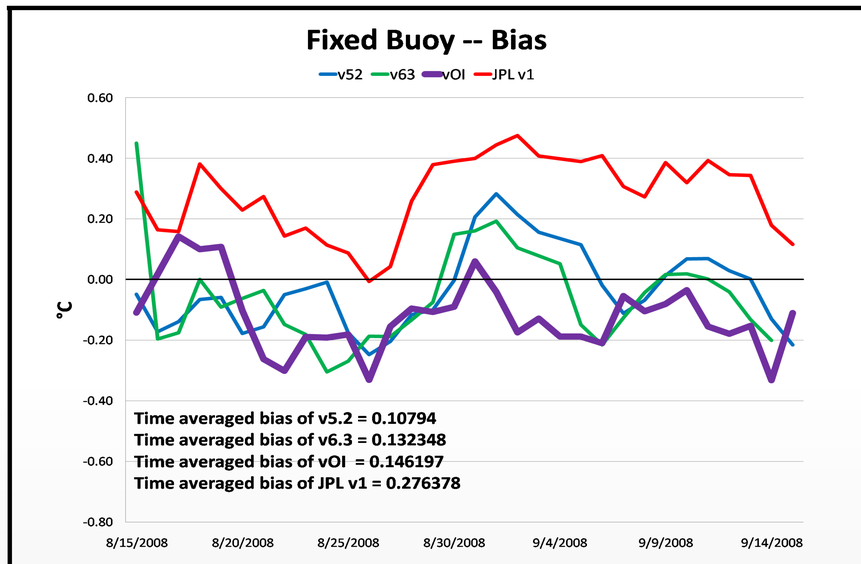
•Period presents challenge because of multiple hurricanes and tropical storms moving through domain

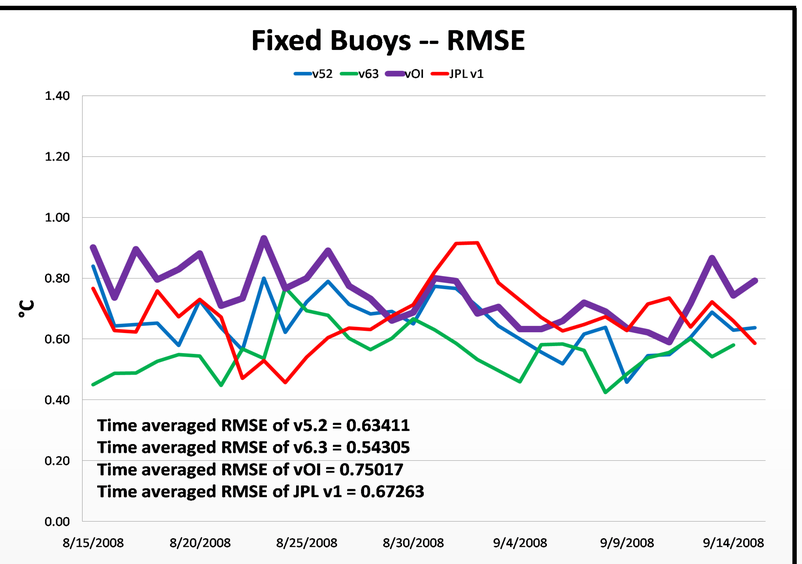
• RTG analysis used as initial background and previous day's analysis subsequently in lieu of

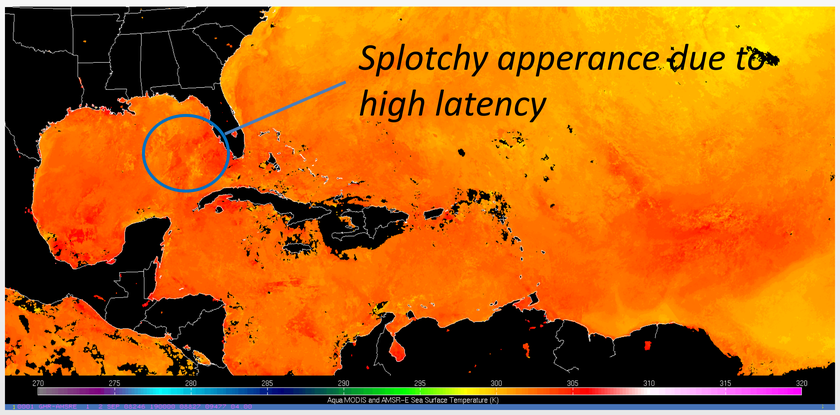
• Background variance inflated each day by an empirically determined constant

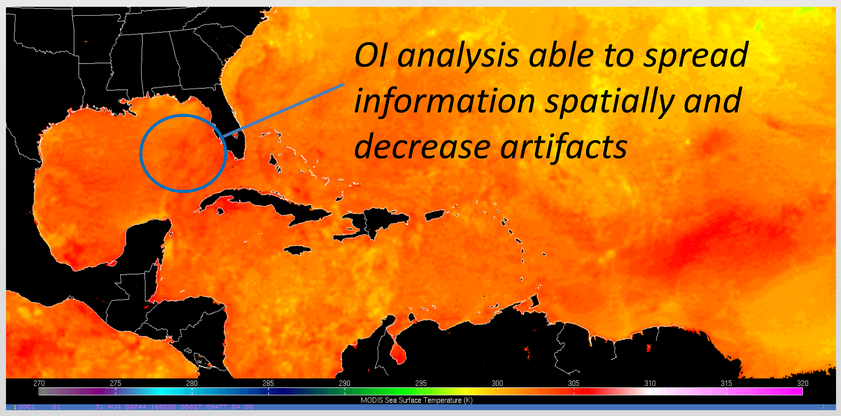
• Observations assimilated sequentially

• Correlation length scale varies based on number of available observations in surrounding 70km x 70km box

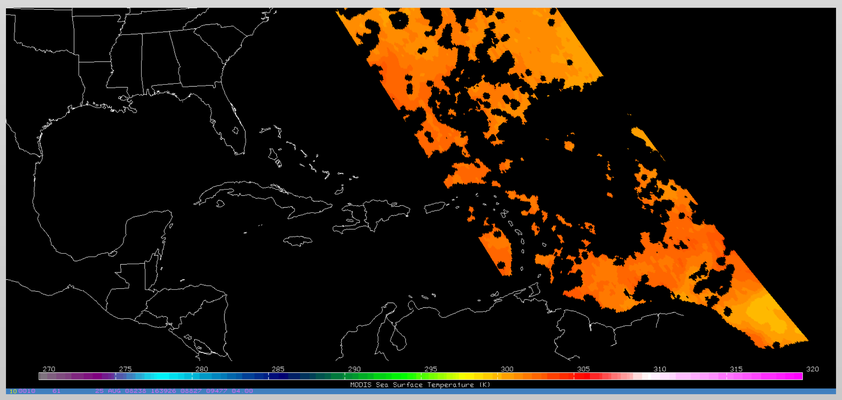








Comparison of v52 composite (top) and OI analysis (bottom)



Representation of gridded obs used in assimilation scheme

V5.2 *– MODIS with 20% AMSR-E weighting (prox 4-5 allowed, 7-day composite)*
V6.3 *– MODIS with 20% AMSR-E and 20% OSTIA weighting (prox 4-5 allowed, 7 day composite)*
VOI *– Optimal interpolation analysis, variable correlation length scale*
JPL v1 *– MODIS with 25% AMSR-E weighting (prox. 5 allowed, 7-day composite)*

Results

• Validation against both drifting and fixed buoys to compare analysis to in situ observations

• OI technique compared favorably with SST products that use a compositing technique in both bias and RMSE

• Validation against drifting buoys (not shown) show slightly higher bias (~0.12 K) and RMSE (~0.17 K) than compositing techniques, but still compares favorably because of uncertainties in validation due to sparse in situ data

• OI reduces small scale "artifacts" in areas with higher data latency

• Tuning length scale to longer lengths produces consistently smoother analysis product, but has yet to be validated

• OI schemes with shorter correlation length scales struggle in large cumulus fields due to lower number of observations, often producing a speckled appearance

Summary

• OI analysis used to produce high spatial and temporal resolution SST analysis

• Variable length scale used based on number of available observations in predetermined radius

• Technique reduces artifacts in areas of high latency and validates favorably against SST compositing techniques

•Future work will include continued tuning of parameters and extension of technique to other domains and seasons

Selected References – Cummings, J., Operational multivariate ocean data assimilation, *Q.J.R. Meteorol. Soc.*, **131**, 3583-3604, 2005; Reynolds, R. and T. Smith, Improved global sea surface temperature analyses using optimum interpolation, *Journal of Climate*, **6**, 929-948, 1994; Minnett, P.J., Evans, R.H., Kearns, E.J., & Brown, O.B., Sea-surface temperature measured by the Moderate Resolution Imaging Spectroradiometer (MODIS), *Geoscience and Remote Sensing Symposium*, 2002. IGAARS '02. 2002 IEEE International, **2**, 1177-1179

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